(1983).

FIG. 1a FIG. 1b

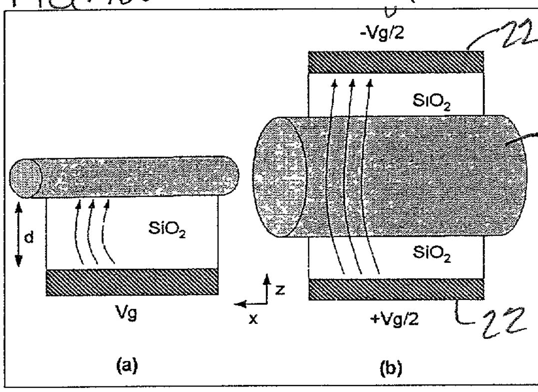


FIG. 2

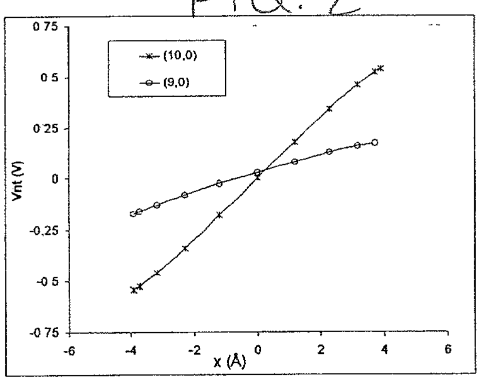


FIG. 3a

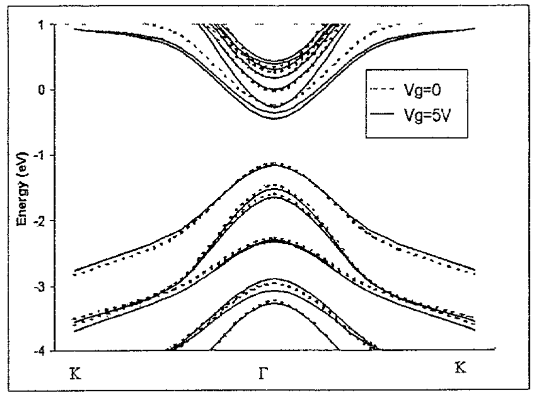


FIG. 3b

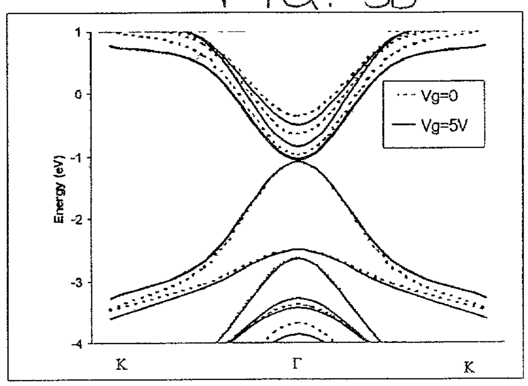
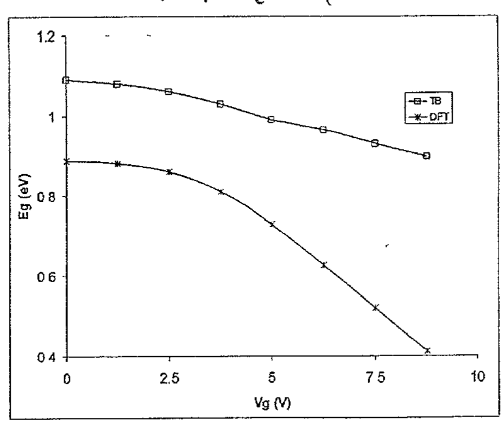
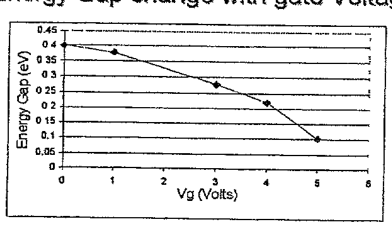


FIG. 4



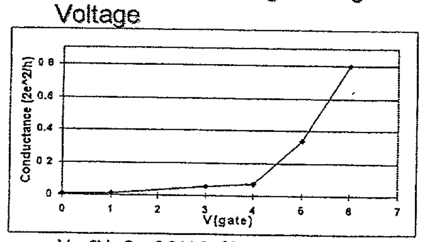
Energy Gap change with gate Voltage



• Energy gap reduces from 0.4eV to 0.1eV

FIG.5

Conductance change with gate Voltage



• Vg=0V C = 0.011 2 e^2/h

• Vg=6V C = 0.81 2 e^2/h

FIG.6

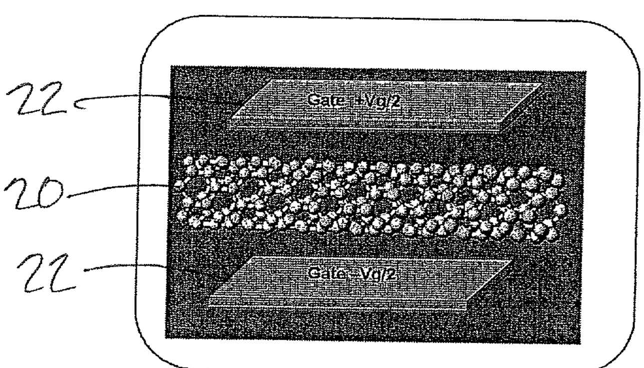

22
Gate +Vg/2
20
22
Gate -Vg/2

FIG. 7(a)

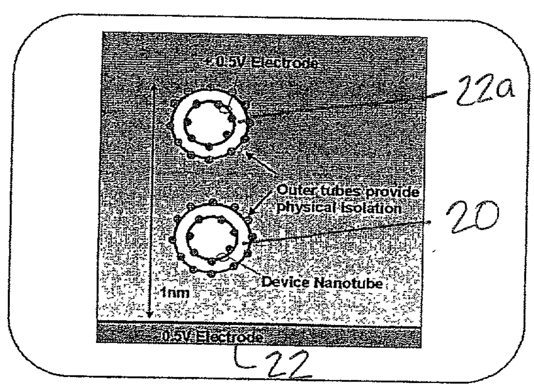
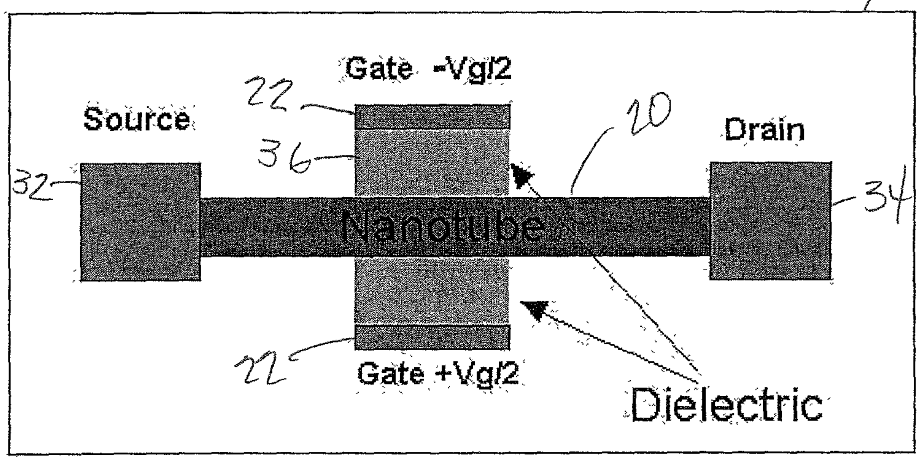

+0.5V Electrode
22a
Outer tubes provide physical isolation
20
Device Nanotube
1nm
-0.5V Electrode
22

FIG. 7(b)

FIG. 8

1. Nanotube Field Effect switch 30



- The split-gate generates a potential gradient about the tube X-section.
- The energy-gap narrows as a result of the potential gradient.
- This causes a change (increase) in the source-drain conductance.
- The gate can be across part or all of the nanotube.

Variations on nanotube field effect switch

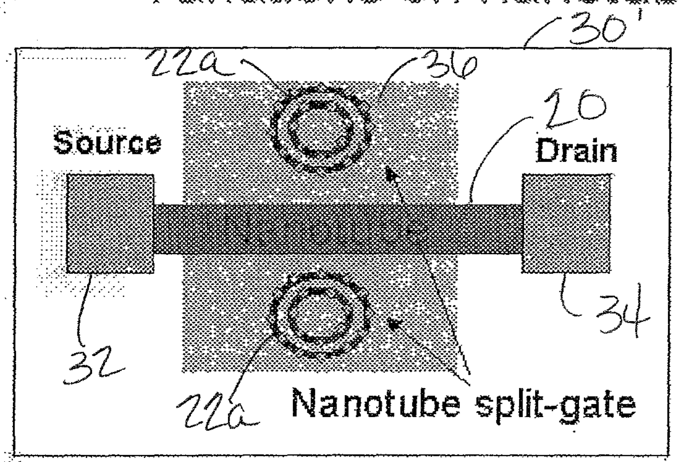


FIG. 9 (a)

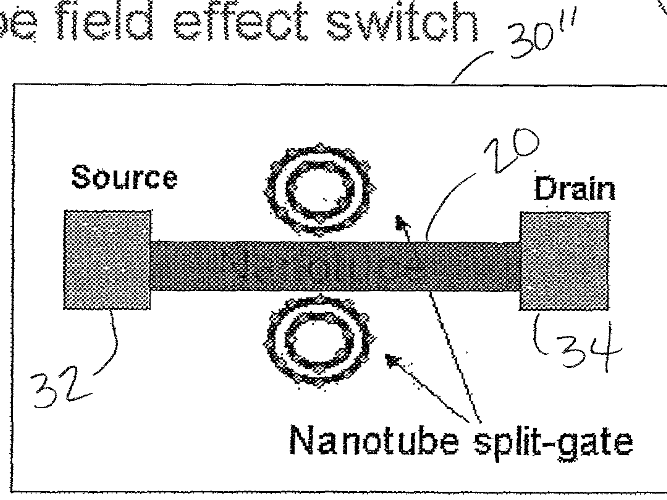


FIG. 9 (b)

- A) Single or multi-wall tubes are used as gate electrodes. There is a dielectric (SiO_2 etc.) between the tubes.
- B) Same as (a) except the is no gate dielectric. The tubes form a crossing junction. There is capacitor action because there is only weak inter-tube conductance.

3. Modulated optical absorption

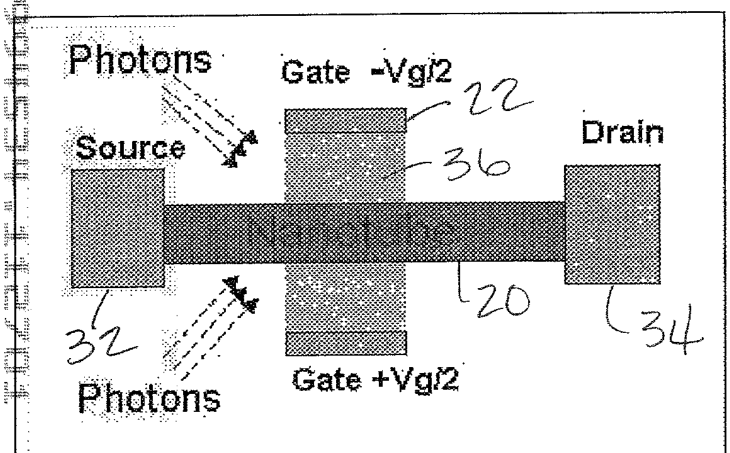


FIG. 10(a)

- The potential gradient narrows the energy gap and therefore shifts the optical absorption edge (illustrated in (b) for three different gate voltages)
- The energy gap and band-structure can be tuned to absorb specific photon energies. Electron-hole pairs are created when the photons are absorbed and results in a source-drain current. This is a typical photo-detector operation, except that it is tunable using energy gap modulation

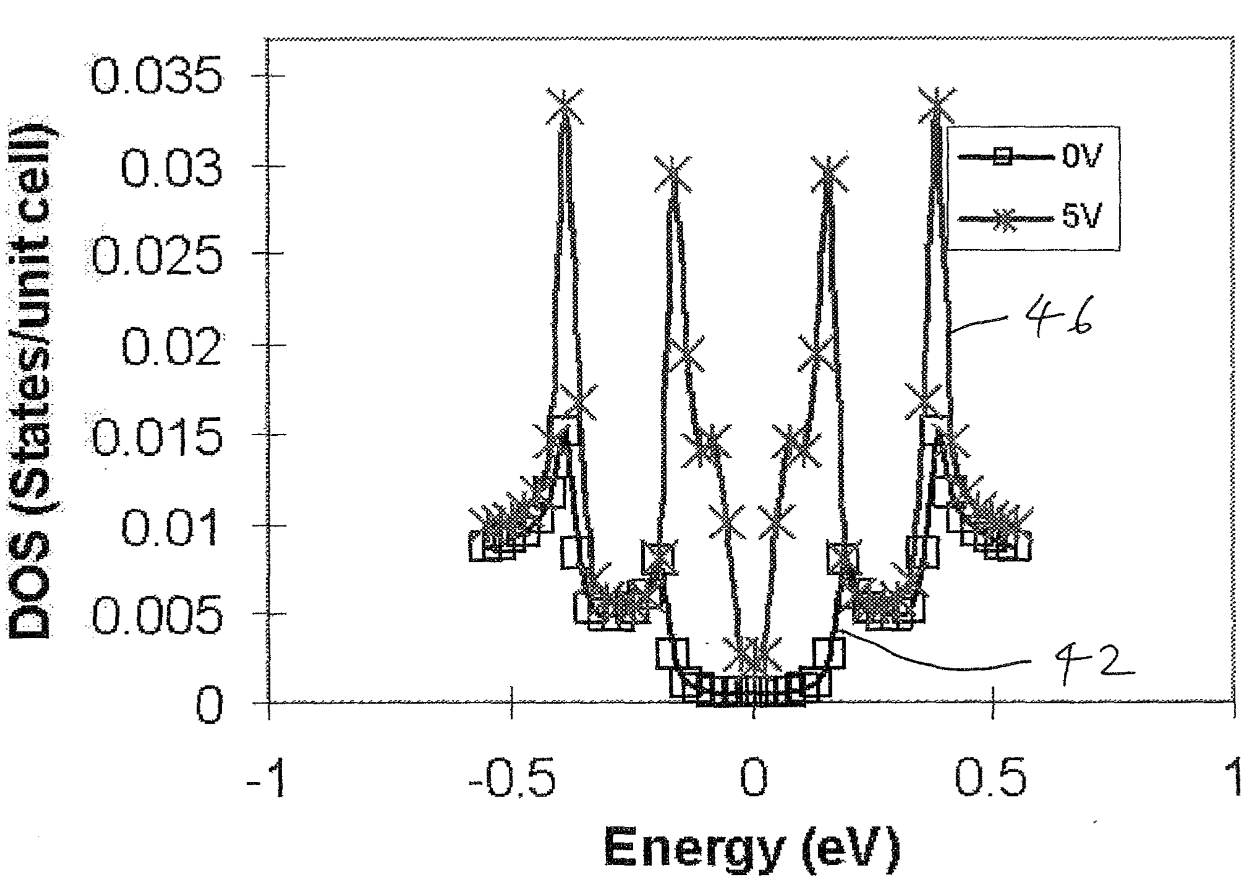
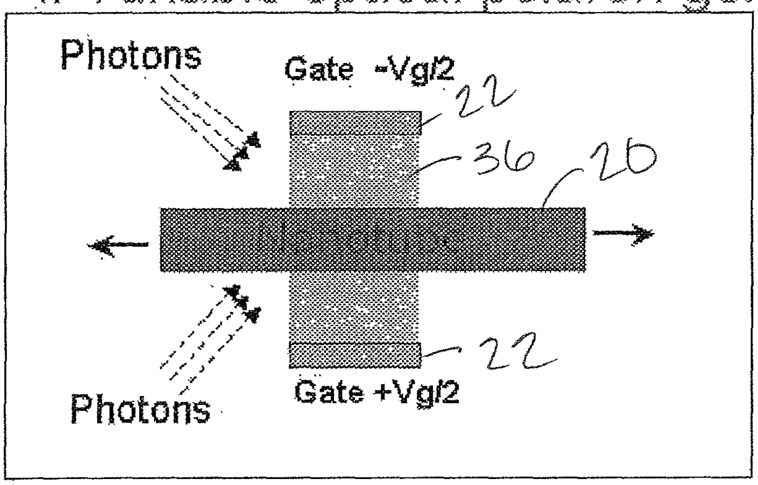

DOS (States/unit cell)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-1
-0.5
0
0.5
1
Energy (eV)
0V
5V
46
42

FIG. 10b

FIG. 11

4. Tunable optical polaron generator



- Electron hole pairs are generated when the photons are absorbed.
- The electron hole pairs form polarons which cause the tube to deform mechanically (elongate or bend).
- Our claim is that we can control this process by modulating the amount of photon absorption.

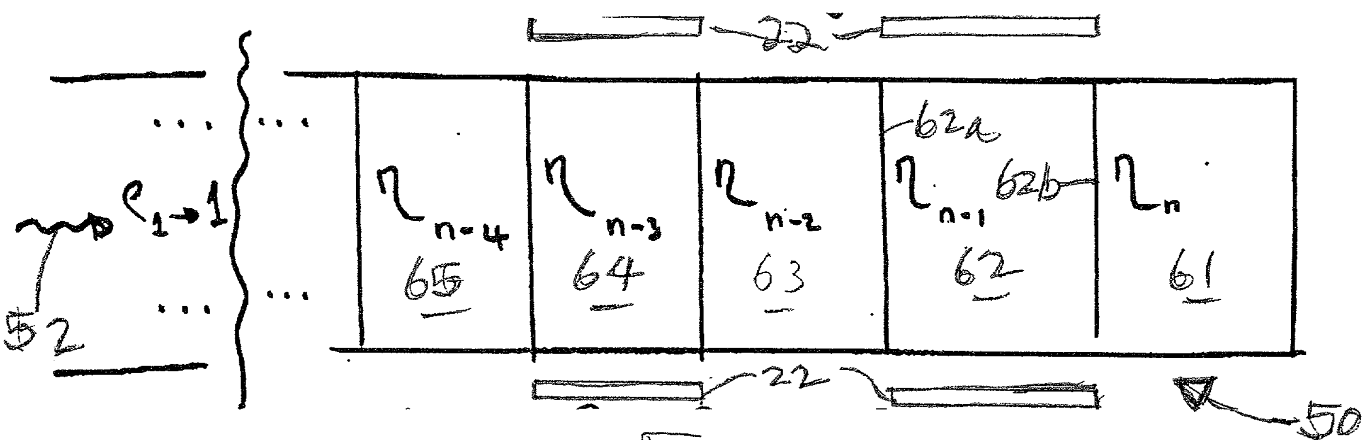

22
22
22
62a
62b
η_{n-4}
65
η_{n-3}
64
η_{n-2}
63
η_{n-1}
62
η_n
61
$e_1 \to 1$
52
50

FIG. 12

FIG. 13

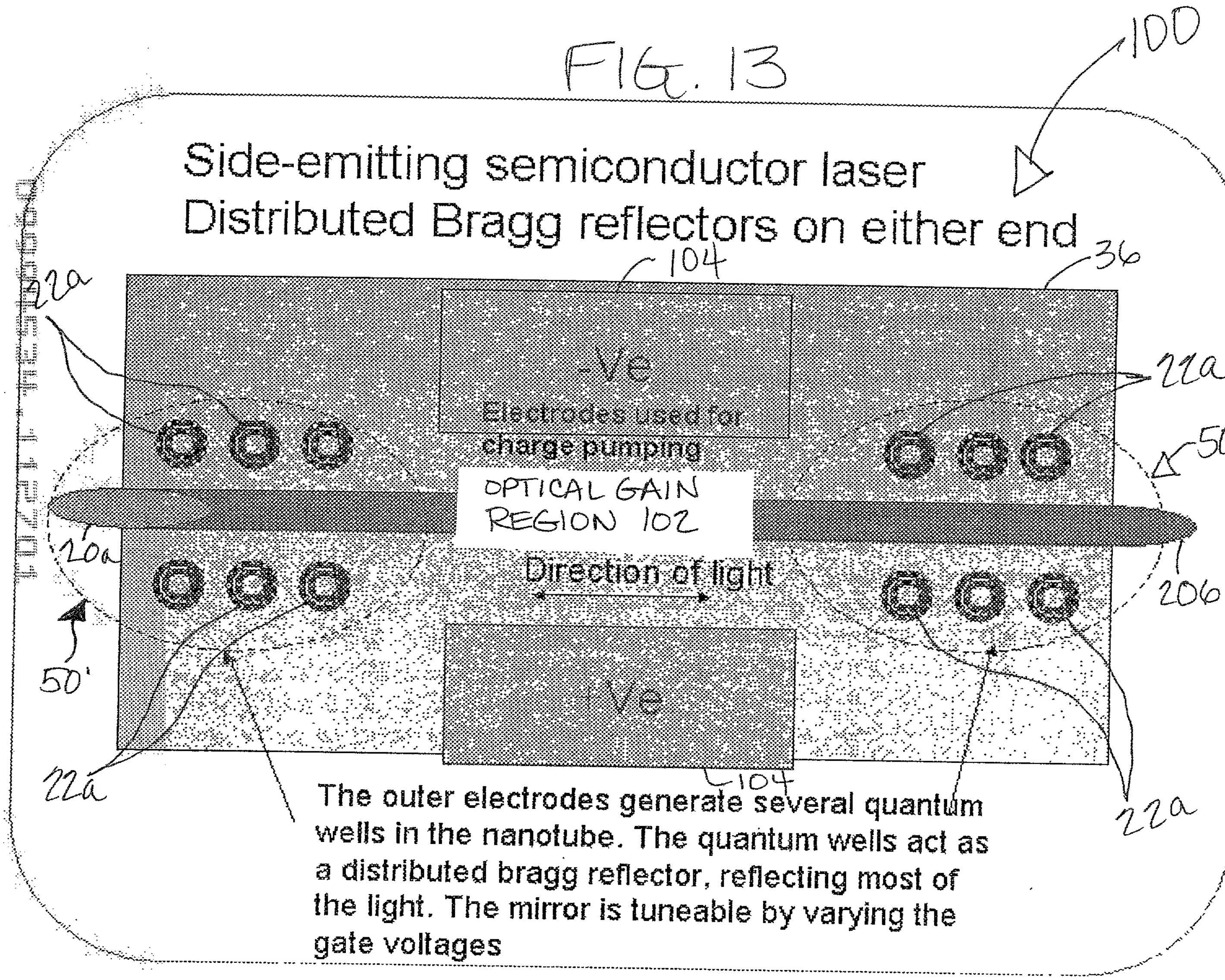

100
Side-emitting semiconductor laser
Distributed Bragg reflectors on either end
104
36
22a
-Ve
Electrodes used for
charge pumping
22a
50'
OPTICAL GAIN
REGION 102
20a
Direction of light
206
50'
+Ve
22a
104
The outer electrodes generate several quantum wells in the nanotube. The quantum wells act as a distributed bragg reflector, reflecting most of the light. The mirror is tuneable by varying the gate voltages
22a

FIG. 14a

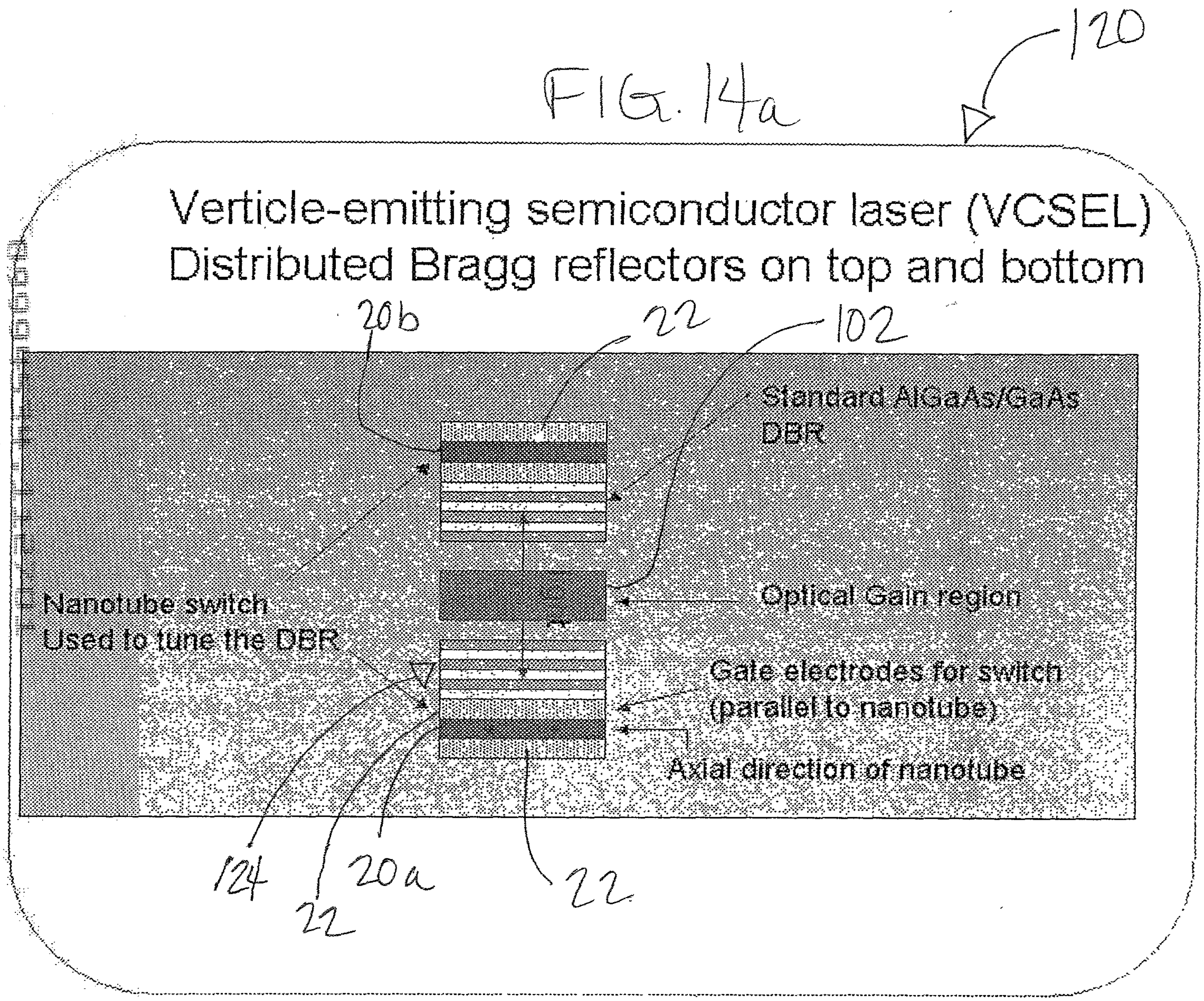
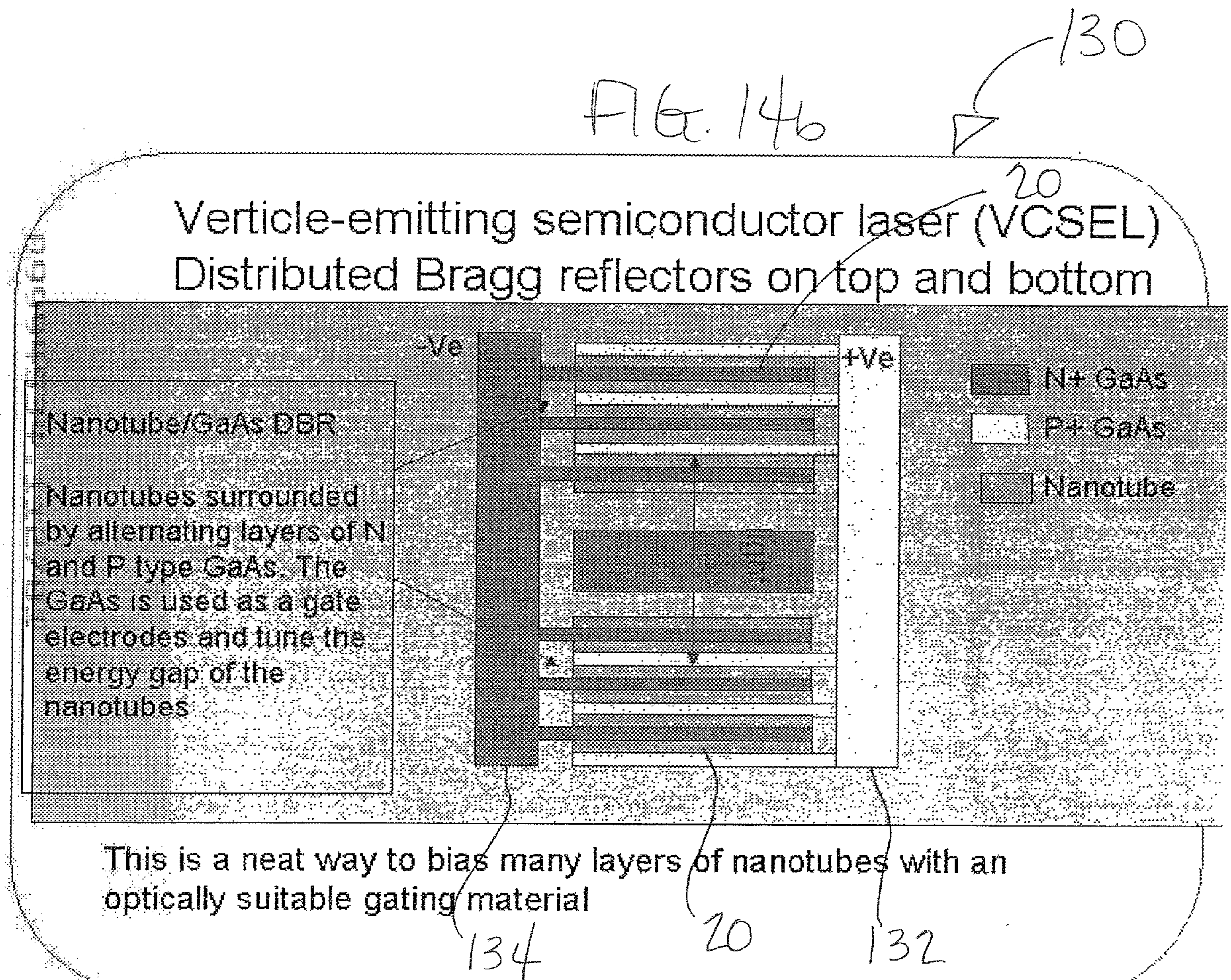
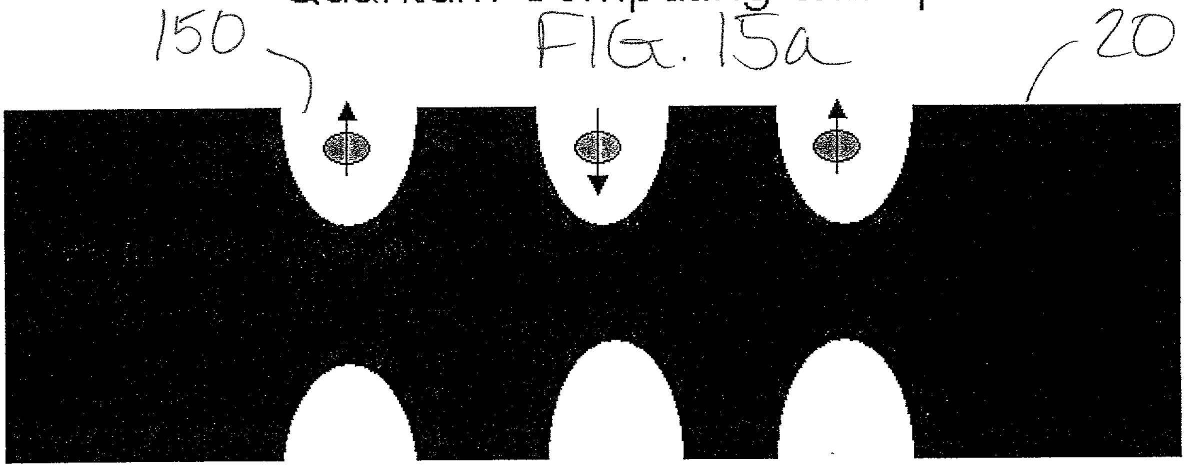

120
Verticle-emitting semiconductor laser (VCSEL)
Distributed Bragg reflectors on top and bottom
20b
22
102
Standard AlGaAs/GaAs DBR
Optical Gain region
Nanotube switch
Used to tune the DBR
Gate electrodes for switch (parallel to nanotube)
Axial direction of nanotube
124
22
20a
22

FIG. 14b


130
20
Verticle-emitting semiconductor laser (VCSEL)
Distributed Bragg reflectors on top and bottom
-Ve
+Ve
N+ GaAs
P+ GaAs
Nanotube
Nanotube/GaAs DBR
Nanotubes surrounded by alternating layers of N and P type GaAs. The GaAs is used as a gate electrodes and tune the energy gap of the nanotubes
This is a neat way to bias many layers of nanotubes with an optically suitable gating material
134
20
132

Quantum Computing example

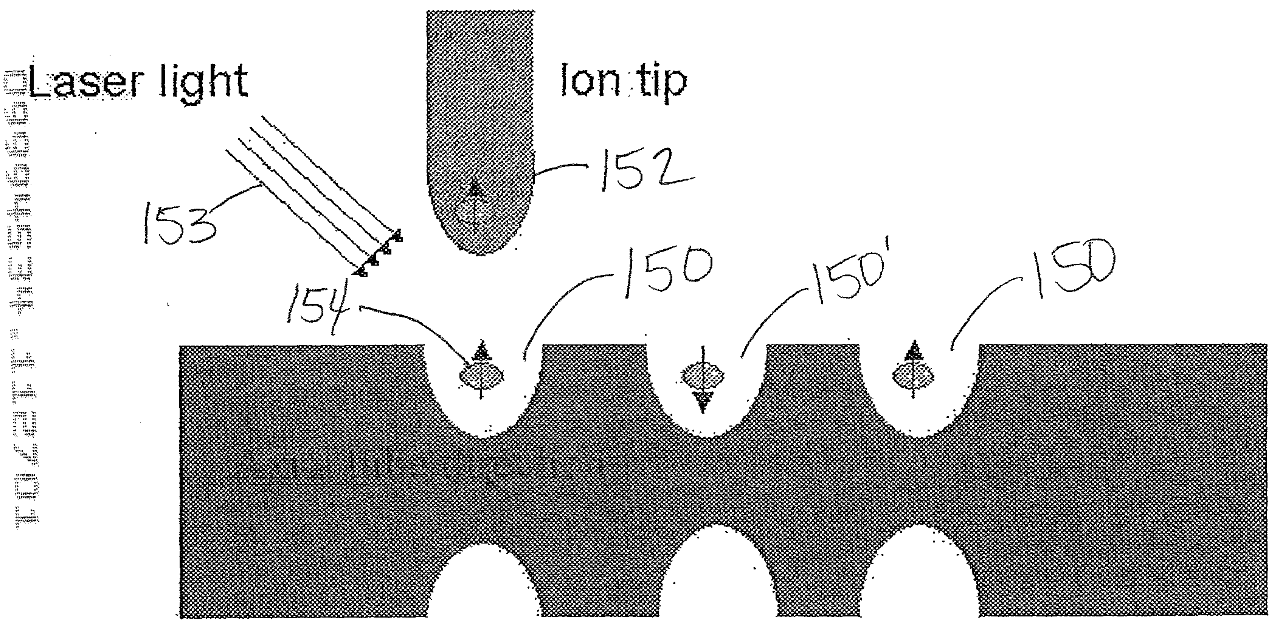
FIG. 15a



•Multiple quantum wells are created along the tube.
•In this example the spins in the outer wells are used to manipulate the spins in the center well.
• The wells used to store confine electrons in well defined spin states i.e. ↑ Or↓

FIG. 15b

Quantum Computing example: Reading and Writing



•Using a laser pulse in conjunction with an ion tip, the electron spin state from the tip is placed onto the Q-well
•When the laser is off the state in the Q-well is read by the ion tip.